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Criticality Safety Evaluation of the Creation of SCCC Hx under OSP 332.191

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TO: CSS Files, L-128

FROM: Harvey Goldberg *Harvey Goldberg*

SUBJECT: **Criticality Safety Evaluation of the Creation of SCCC Hx under OSP332.191**

1.0 INTRODUCTION

The purpose of the operations analyzed herein is to conduct neutron and γ -ray measurements on arrays of Measurement Standard Assemblies (MSAs) (AAAOO-104994), which are filled with plutonia (PuO_2). These arrays will be surrounded by a plastic compound. This analysis ascertains the criticality safety of this operation. These operations will be carried out in Workstation 1309 in Room 1313 of Building 332, in accordance with OSP 332.191. In order to accommodate these operations, the program has requested the creation of a new SCCC, designated Hx.

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<i>UNCLASSIFIED</i>
CLASSIFICATION DETERMINATION
<i>John S. Pearson, physicist</i> Authorized Derivative Classifier
<i>CH-DAR-2 and COR-2001-600</i> (9/2001)
Source Guide

2.0 DESCRIPTION OF THE OPERATION

The Measurement Standard Assembly (MSA) (AAA00-104994) is a hexagonal material container developed at the Lawrence Livermore National Laboratory (LLNL) for the packaging of special nuclear material (SNM) in its oxide form. The container is nominally 9.49 cm (3.74"), flat surface-to-flat surface, 10.75 cm (4.23") corner-to-corner, and 10.67 cm (4.20") in length, and is constructed out of 316L stainless steel.

The interior of the container can be accessed through two holes in one of the flat sides (nominal 3.8 cm and 1.27 cm diameter). The maximum amount of plutonia that will be loaded into each container is 3.6 kg. This would correspond to 3.09 kg of plutonium. It is doubtful if this amount of material could be loaded into this container, but it was used as a conservative estimate of the loading.

Various arrays of these assemblies will be constructed and their emitted radiation will be measured either bare or surrounded by plastic outside of the array. The array was analyzed in its most reactive configuration. Thus, any other configuration will be less reactive.

3.0 METHODOLOGY

The Monte Carlo computer program, MCNP4b (Briesmeister, 2000), was used to calculate the reactivity (k_{eff}) of various arrays of filled cans. Calculations were performed on a Sun Ultra Spark 60, Model 1360 computer (Godiva) using the endf/b-vi cross section set. A selected set of benchmark experiments (NEA, 1998) were run on this machine. These benchmarks included metal, solution, polystyrene moderated, and mixed oxide fuel systems. Pure PuO₂ systems were not available. From the results a bias was estimated. Results are tabulated below in Table 1.

Table 1: Bias Calculations

Name	Description	Published k_{eff}	Calculated k_{eff}
Pu-SOL_THERM-002	H ₂ O reflected 12" dia Sphere of Pu(NO ₃) ₂	1.0000 ± .0047	1.00949 ± .00098
Pu-SOL-THERM-006	H ₂ O reflected 15" dia Sphere of Pu(NO ₃) ₂	1.0000 ± .0035	1.00444 ± .00086
Pu-SOL-THERM-010	H ₂ O reflected 11" dia Cylinder of Pu(NO ₃) ₂ *	1.0000 ± .0048	1.02188 ± .00102
Pu-Met-Fast-023	Graphite reflected Sphere of δ-phase ²³⁹ Pu	1.0000 ± .0020	0.99778 ± .00059
Pu-Met-Fast-032	Steel reflected Sphere of α-phase ²³⁹ Pu	1.0000 ± .0020	1.00312 ± .00061
Pu-Met-Fast-040	Copper reflected Sphere of α-phase ²³⁹ Pu	1.0000 ± .0038	1.00089 ± .00089
Pu-Comp-Inter-001	k_{∞} for ²³⁹ Pu, Intermediate Neutron Spectrum	1.0000 ± .0011	1.01000 ± .00054 (NEA value 1.0105)
Pu-Comp-Mixed-001	Unreflected Slabs of Polystyrene Moderated PuO ₂	0.9986 ± .0041	1.0300 ± .00094 (NEA value 1.0300)
Pu-Comp-Mixed-002	Plexiglass Reflected Slabs of Polystyrene Moderated PuO ₂	0.9990 ± .0046	1.0310 ± .00080 (NEA value 1.032)
Mix-Comp-Therm-007	Array of mixed oxide fuel pins	1.0000 ± .0044	0.98872 ± .00051

* published data are for various diameter cylinders. This was the highest calculated result of the set.

Since the calculational results are, on the average, larger than the published results, the bias ($k_{\text{Pub}} - k_{\text{Calc}}$) will be negative. However, for conservatism, only the cases with positive biases were used. The average of these two biases (.00222 for Pu-Met-Fast-023, and .01128 for MIX-COMP-THERM-007) was .00675.

The standard deviation was calculated using the square root of the sum of the maximum of the published k_{eff} s and the maximum of the calculated k_{eff} s. Again, this is a conservative estimate.

$$\sigma = \frac{1}{2} \sqrt{\sigma_c^2 + \sigma_p^2} = \frac{1}{2} \sqrt{(0.0048)^2 + (0.00102)^2} = .0025$$

Choosing a safety margin of 2%, we get, for the safety limit,

$$\begin{aligned} SL &= 1 - \text{Bias} - 3\sigma - \text{Safety Margin} \\ &= 0.9657 \end{aligned}$$

4.0 NORMAL AND PROCESS UPSET CONDITIONS

4.1 Normal Operations

Various arrangements of MSA containers will be used. Linear arrays of containers will be placed, either one or two cans high, surrounded by plastic, in an aluminum frame with an aluminum sleeve (~0.15 cm thick) for positioning the containers. The space between the hexagonal containers and the square sleeve, as well as caps on either end of the linear array will be LEXAN, a polycarbonate ($\text{OC}_6\text{H}_4\text{C}(\text{CH}_3)_2\text{C}_6\text{H}_4\text{OCO}$). Since it will be the plastic that is in contact with the SNM, this bit of LEXAN will not be considered.

The proposed plastic is RM-104-AOC. This material has a density of 1.27 g/cm³ and is composed of 20 wt% Ammonium Nitrate (NH_4NO_3), 45 wt% Tartaric Acid ($\text{C}_4\text{H}_6\text{O}_6$), 10 wt% Melamine ($\text{C}_3\text{H}_6\text{N}_6$), and 25 wt% XP-1187 ($\text{C}_{5.3}\text{H}_{5.3}\text{O}_{2.0}$). This leads to the following atomic weight percentages;

Table 2: Elemental Composition of RM-104-AOC	
Element	Weight Percentage
H	4.62%
C	33.02%
N	13.66%
O	48.70%

Although this degree of packing is highly unlikely, the maximum of 3.6 kg of PuO_2 was assumed to be in the container, giving a density of 4.50 g/cm³ for the plutonia. In order to achieve this density the material would have to be tamped down forcibly. This is impossible to achieve over the entire volume of the container with the only entry to the interior being a hole on one side.

In addition to the linear arrays, there will be arrays of containers in shapes approximating a spherical shape, surrounded by plastic. At the request of the customer, the most reactive arrangement of containers was analyzed bounding any other arrangements. This arrangement would be an approximately spherical shape.

Calculations have indicated that no more than nine containers would meet the subcritically safe limit. These results investigating the most reactive arrangement of these nine are tabulated in Table 3. The containers are arrayed in three layers with their hexagonal sides touching each other. They are surrounded by an infinite, close fitting plastic reflector.

Table 3: Array Shape Investigation

# Cans in Layer	k_{eff}	σ	Run I.D.
4/5/0	0.8619	.0027	9lathe0d
3/3/3	0.8519	.0031	9lathe0c
2/5/2	0.8626	.0024	9lathe0b
1/7/1	0.8781	.0022	9lathe0a
0/9/0	0.8481	.0025	9lathe0e

The most reactive arrangement was found to be seven cans in one layer arranged in a hexagonal pattern (i.e. a central can surrounded by six nearest neighbors) with one can above and below. (See Figures 1, 2, and 3, below.) These analyses lead to the limit that the number of loaded MSA containers to be allowed in the room at any one time will be limited to nine. Nine MSA containers surrounded by a large number, essentially an infinite number, of RM-104-AOC will be considered as the normal operation. There may be fewer containers, but no more. The plastic will be in the same shape and size as the MSA can so that close packing could be achieved.

08/12/03 15:22:57
Nine "nisch" Cans in a RH-05-R3
Lattice

probid = 08/12/03 15:21:58
basis:
(1.000000, 0.000000, 0.000000)
(0.000000, 1.000000, 0.000000)
origin:
(0.00, 0.00, 0.00)
extent = (100.00, 100.00)

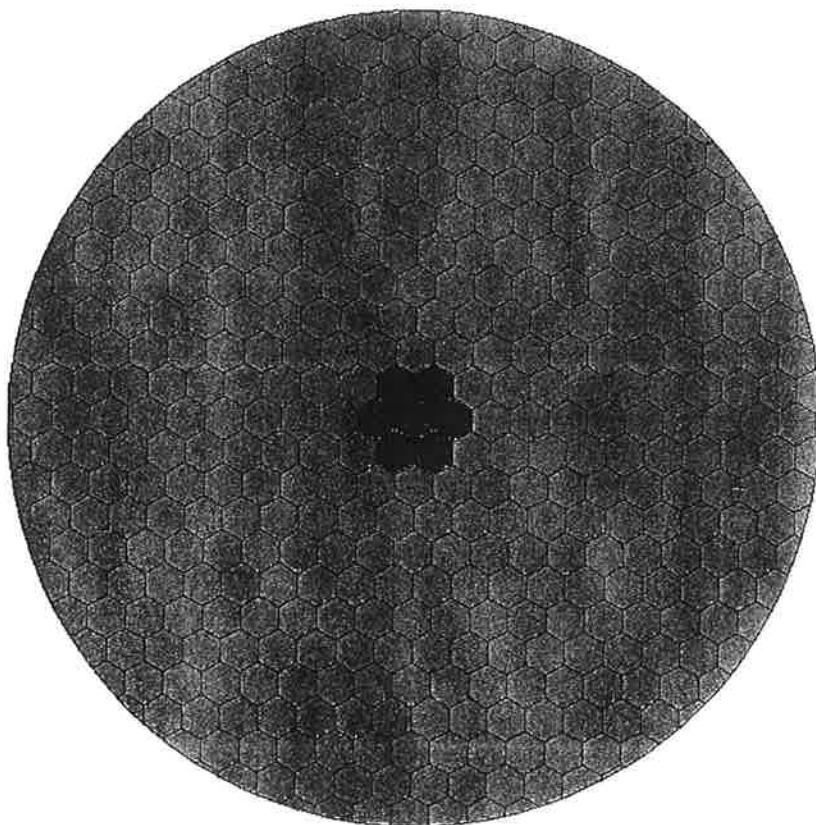


Figure 1: Center layer of cans (x-y view)

```
08/12/03 15:28:59
Three "Rich" Cans in a RF-05-H3
lattice

probid = 08/12/03 15:21:58
basis:
( 1.000000, 0.000100, 0.000000)
( 0.000000, 0.000100, 1.000000)
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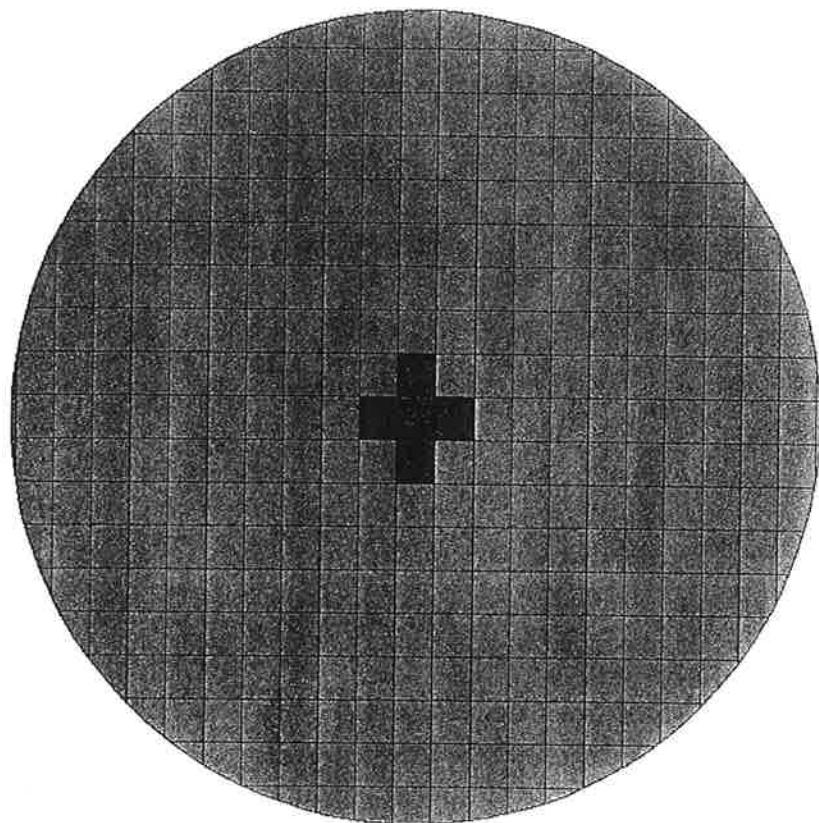


Figure 2: Three Cans Layers (x-z view)

```
08/12/03 15:30:12
Nine "Bish" Cans in a RM-05-R3
Lattice

probid = 08/12/03 15:21:58
basis:
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extent = ( 100.00, 100.00)
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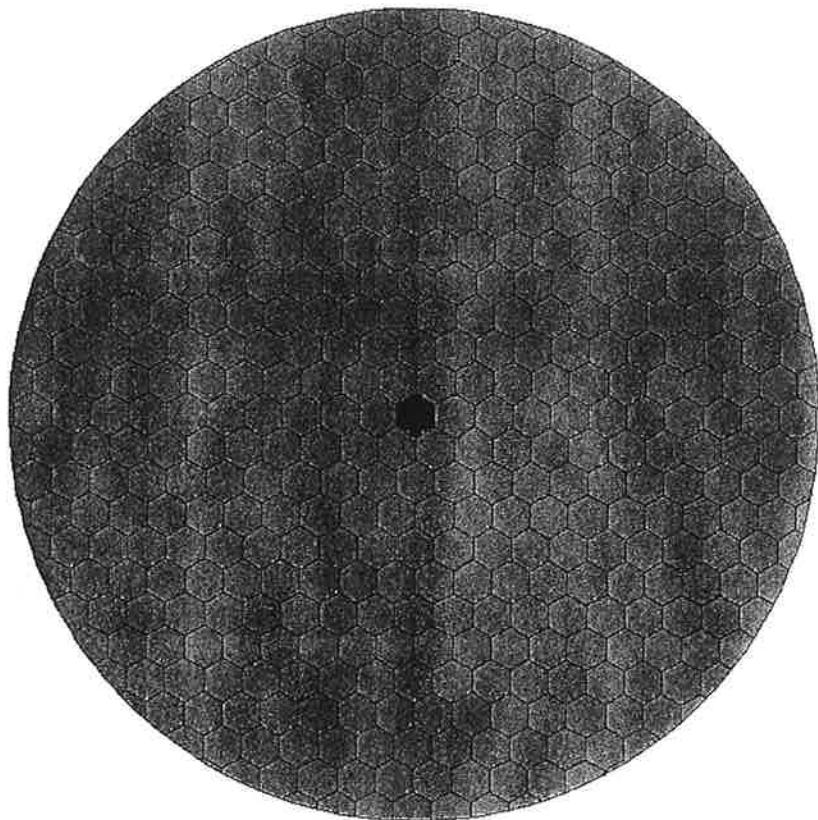


Figure 3: Upper and Lower Layer of Cans (x-y view)

4.2.1 Loss of Moderation and Spacing Control : An increase in the spacing between individual containers was investigated. While some space will exist between the containers, the investigation was extended beyond the bounds of credibility.

Although it can be argued that this is a second contingency, the space between the separated containers was modeled as being filled with water. The spacing and water created a situation of interstitial moderation between finite elements of fissionable material. The worst possible separation was found which will certainly bound any credible condition. At this spacing filling the space with plastic rather than water was investigated. This proved less reactive than filling the space with water.

While a flooding of the apparatus is beyond extremely unlikely as there are no boundaries around the array that can hold water, when the separation is small, these gaps could fill with water, which is in the process of flowing from the top to the bottom of the array.

It is considered beyond extremely unlikely that the containers could be crushed to the extent that water could seep into them. The side walls of the container are a nominal 0.12 cm (0.048") thickness of steel and the ends are a nominal 0.46 cm (0.18") thickness of steel. There is nothing in the immediate vicinity of the proposed operations that could fall and compromise their integrity.

The plastic is flammable and could sustain a fire. It would melt as it burned and would not produce a fire immediately around the container array, although it would burn immediately below the array. The containers have been fire tested and maintained their integrity at least up to 800°C, producing a pressure of ~100 psi inside the container.

4.2.2 Loss of Mass Control : While, as stated above, it would be very difficult to load a container with 3.6 kg of plutonia, the contingency that one container, the middle one, was filled with 6.02 kg of oxide (5.31 kg of Pu) was investigated. To do this would entail packing to a density of 7.52 g/cm³, which would take a great deal of effort. This is an beyond extremely unlikely scenario, but is used as an accidental upset. It could only be achieved as a deliberate effort to sabotage the process. The loading of an extra can into the array is a more likely scenario, and has been investigated.

One scenario involving multiple contingencies is the scenario wherein each time a can is loaded the scale misreads and 4.0 kg of plutonia is loaded into all of the cans. This would entail an inaccurate scale over the production of nine loaded cans, extending over a week or more. This would also entail a density of 5 g/cm³ which would be rather difficult, although less difficult than the 7.52 g/cm³ assumed in the double massed can scenario.

4.2.3 Loss of Reflector Control: The analysis has approximately 81 cm (~2.66 feet) of plastic as a close fitting reflector on all sides. This represents more than is planned to be used, or that can be used considering the space in the laboratory. This is a more reactive reflector than water. A 2.4% increase in the density of the plastic was also investigated. It is beyond extremely unlikely that a large, spherical shell of some worse reflector, such as beryllium (radius ~27 cm [10. inches]) could accidentally surround the array of containers with or without the plastic reflector.

4.2.4 Loss of Containment due to a Thermal Excursion: The addition of a large amount of plastic raises the thermal loading of the experimental setup. The pressurization of the MS containers due to heating was investigated. The cans will be filled with plutonium, which will have been calcined at a temperature of 1000°C and protected from moisture until it is sealed in the MS container.

While it is extremely unlikely that significant moisture would be entrapped in the container, uncertainties could allow up to 1.44 g of H₂O to be in the sealed container. Heating of this amount of H₂O, along with He and N₂, to a temperature of 800°C is expected to produce an internal pressure of 252 psia (See Appendix C). A production certified container was pressurized to 1100 psig and did not fail. The strength properties of the can material decrease ~25% at this temperature, which makes this room temperature test equivalent to a heated test of 825 psig. This represents a safety factor of 3.5 over the expected internal pressures at this temperature.

Thus, a fire induced failure of the MS container is considered as a beyond extremely unlikely contingency for this system and will not be considered further.

5.0 ANALYSIS

5.1 Normal Conditions

The loss of spacing/moderation scenario resulted in a limit of nine containers for safety. Thus, the operation will be limited to this number. Nine containers in their most reactive configuration, approximating a spherical shape as closely as possible, surrounded by an essentially infinite reflector of plastic in intimate contact with the array on all sides yields a k_{eff} of 0.8805 ± .0026 (Run 9lathe0a), which is substantially less than the safety limit.

5.2 Contingency analysis

The contingencies considered have been described in the previous section and are tabulated in Table 5. The operation was found to be subcritically safe with respect to the double contingency methodology.

5.2.1 Loss of Moderation and Spacing Control : An analysis was performed to find the maximum reactivity when the containers, still in a hexagonal array, are separated from each other. The space between the cans was filled with water. This analysis was carried out using various numbers of containers in various configurations. The highest k_{eff} was found to be 0.9517 at a spacing of 1.25 cm (Run lathe1p25).

**Table 4: Spacing Study for 9 Containers
with Water Between Them**

Spacing (cm)	Run	k_{eff}	σ
0.00	9lathe0a	0.8782	.0022
0.50	9lathe0p5	0.9207	.0029
0.75	9lathe0p75	0.9456	.0032
1.00	9lathe1p0	0.9488	.0031
1.25	9lathe1p25	0.9517	.0025
1.50	9lathe1p5	0.9479	.0032
2.00	9lathe2p0	0.9164	.0024
2.50	9lathe2p5	0.8632	.0028
3.00	9lathe3p0	0.8124	.0029
3.50	9lathe3p5	0.7598	.0026
4.00	9lathe4p0	0.7173	.0024

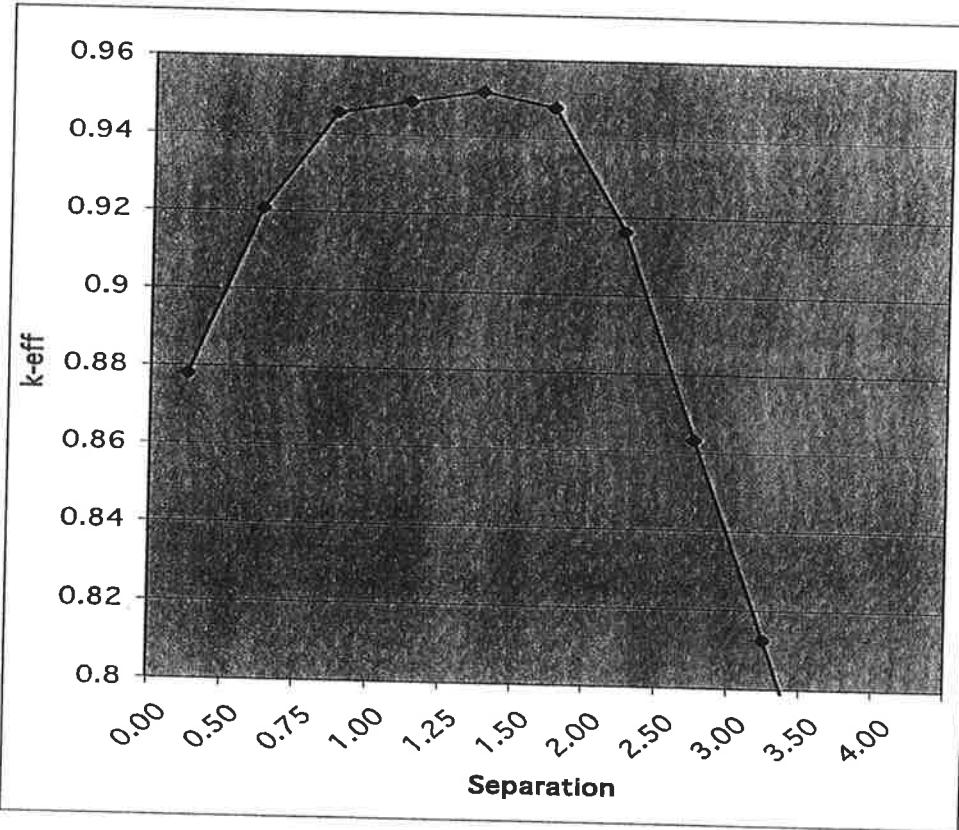


Figure 4: Spacing Study for 13 Containers with Water Between Them

This spacing is rather large and would be unattainable since there would be nothing to support the containers unless someone were to deliberately manufacture a lattice with such a spacing. In addition, water would drain so quickly that it would not fill such a space. However, this scenario, which is safely subcritical, would bound any credible scenario.

With plastic rather than water in the gaps between the cans resulted in a lower reactivity, e.g. $0.8669 \pm .0029$ vs. $0.9517 \pm .0025$ (Run 9lathe1p25a). Replacing the center can with plastic and placing the replaced can in the center of the layer above results in a decrease in reactivity, $0.8757 \pm .0025$ vs. $0.8805 \pm .0026$ (Run 9latlathe0). Building a “reactor” with the arrangement shown in Figure 5 will also decrease the reactivity of the system, $k_{\text{eff}} = 0.7128 \pm .0028$ (Run 9lathhe0) due to the isolating effect of the plastic. Note that there are still two other cans in the center of the array above and below the layer shown in the figure. However, these are each also separated by one layer of plastic.

```
04/21/04 13:29:50
Nine "Bish" Cans in a RM-05-H3
Lattice

probid = 04/21/04 13:29:12
basis:
( 1.000000, 0.000000, 0.000000)
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extent = (   100.00,   100.00)
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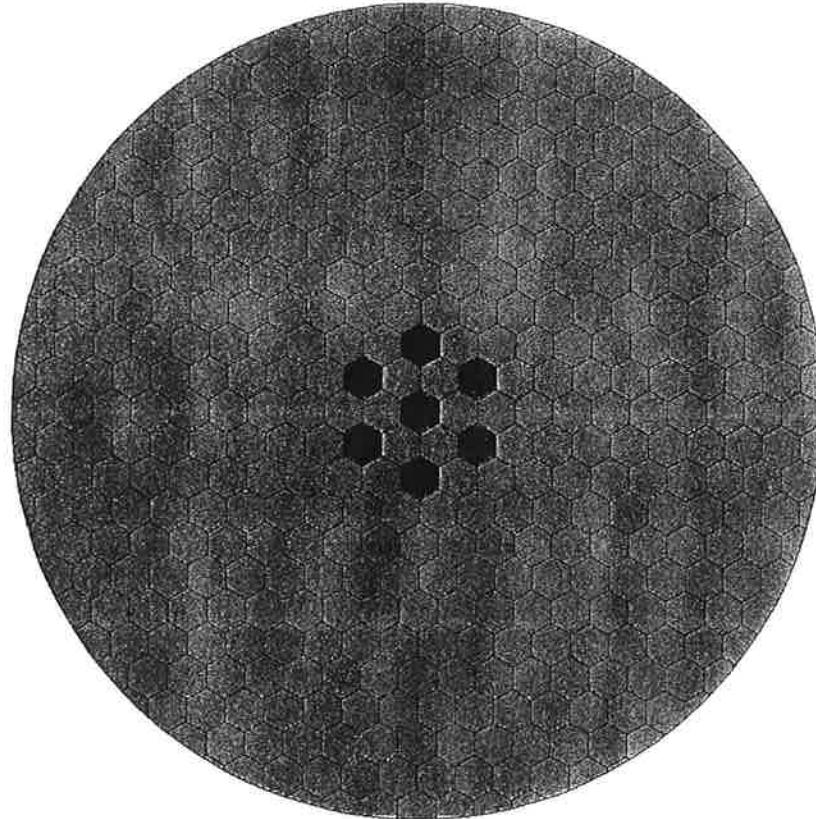


Figure 5: Spreading out of Plutonium Loading (Center Layer)

5.2.2 Loss of Mass Control : Although it is difficult to cram a full 3.6 kg of plutonia ($\rho=4.50 \text{ g/cm}^3$) into the containers, a scenario was calculated wherein the central can of the array was filled with almost twice the allowed mass of plutonia, i.e. 6.02 kg. This number was chosen because, although 3.6 kg is allowed, the present plan is to use no more than 3.0 kg. Thus, this represents twice the planned loading. With this loading the density will be $\rho=7.52 \text{ g/cm}^3$. This would be hard to achieve without a mechanical press and the use of such a press is not credible given the design of the container with such a small filling hole on the side. In this scenario, the reactivity calculated was $0.9433 \pm .0030$ (Run 9lathe0dbl). This is safely subcritical and bounds any credible overmass scenario.

Similarly difficult to accomplish is to load the cans to a density of 5.0 g/cm³, resulting in 4.0 kg of plutonia in a can. If multiple misloadings resulted in a full nine can array being overloaded to this extent the reactivity is expected to be $0.9346 \pm .0028$ (Run 9lathe0f).

Another scenario is that an extra can is stacked in the array. If ten containers were to be loaded into their most reactive configuration, i.e. layers of two, seven, and one containers, the reactivity would only be $k_{\text{eff}} = 0.8969 \pm .0027$ (Run 10lathe0).

5.2.3 Loss of Reflector Control: Infinite intimate reflection by aerial more effective than the plastic is beyond extremely unlikely. However, a 2.4% increase in the density of the plastic was investigated. Plastic with a density of 1.30 g/cm³ will yield a $k_{\text{eff}} = 0.8829 \pm .0030$ (Run 9lathe0r1) which differs from the normal case by less than the standard deviation.

Table 4: Contingency Table

Contingency Description	Affected Parameters	Barriers that Make Contingency Unlikely And Calculational Conservatisms	Controls	Bounding k_{eff} (Case ID)
9 containers in most reactive configuration surrounded by plastic reflector (Normal Case)	Reflection Moderation	Maximum mass allowed (higher than planned mass). Most reactive shape. Infinite HE Reflection.	Each item under SCCC Hx is analyzed. That much plastic will exceed allowed fire loading.	$0.8805 \pm .0026$ (9lathe0a)
10 containers in most reactive configuration surrounded by plastic reflector	Mass	More containers than allowed. Most Reactive Shape. Infinite HE Reflection.	Only nine items allowed under SCCC Hx Two man check of COMATS program	$0.8969 \pm .0027$ (10lathe0)
Same as normal case, but optimal spacing between containers and full interstitial water.	Reflection Moderation	Same as above plus spacing is unphysical and water between the cans is beyond extremely unlikely.	No way to flood the array. Spacing is beyond extremely unlikely.	$0.9517 \pm .0025$ (9lathe1p25)
Same as normal case, but optimal spacing between containers and full interstitial plastic.	Reflection Moderation	Same as above plus spacing is unphysical and water between the cans is beyond extremely unlikely.	No way to insert plastic into the array. Spacing is beyond extremely unlikely.	$0.8669 \pm .0029$ (9lathe1p25a)
Normal Case, but all containers are overmassed.	Reflection Mass	Mass is above allowed mass. Mass is beyond extremely unlikely.	Packing that much mass in the container is beyond extremely unlikely. Loading of multiple cans beyond double contingency.	$0.9346 \pm .0028$ (9lathe0f)
Normal Case, but middle container is overmassed.	Reflection Mass	Mass is above allowed mass. Mass is beyond extremely unlikely.	Packing that much mass in the container is beyond extremely unlikely.	$0.9433 \pm .0030$ (9lathe0dbl)

Table 4: Contingency Table (Cont.)

Contingency Description	Affected Parameters	Barriers that Make Contingency Unlikely And Calculational Conservatisms	Controls	Bounding k_{eff} (Case ID)
Same as normal case, but 2.4% increase in plastic density	Reflection	Maximum mass allowed (higher than planned mass). Most reactive shape. Infinite HE reflection.	Each item under SCCC Hx is analyzed. That much plastic will exceed allowed fire loading.	$0.8829 \pm .0030$ (9lathhe0)
All containers are separated from each other by one plastic unit (like a reactor)	Moderation Form of array	This arrangement is not planned. Most reactive shape Infinite HE reflection.	This is within allowed procedure.	$0.7128 \pm .0028$ (9lathe0r1)

Table 5: Barrier Assessment Table

Barrier	Credit Taken in Analysis ?	Comments
Interaction	Yes	Worst possible arrangement and spacing of containers analyzed.
Poisons	No	
Density	Yes	Conservative density for normal case. Increased density in one container analyzed.
Reflection	Yes	Infinite plastic reflector analyzed.
Geometry	Yes	Geometry of container is fixed.
Volume	Yes	Volume is fixed.
Chemical Form	Yes	Only oxide will be used.
Concentration	No	
Enrichment	No	Pure ^{239}Pu used in analysis.
Moderation	Yes	Interstitial water moderation considered for optimum spacing. Internal moderation is beyond extremely unlikely.
Mass	Yes	Over mass considered; twice expected mass.
Other.	Yes	Approved operations and equipment.

6.0 CONTROLS

A criticality could result in a lethal dose of radiation and the release of radioactive contamination into the environment. The general definitions, special actinide limits, allowance for trace quantities of prohibited materials, and additional criticality safety controls are contained in the building 332 Facility Safety Plan, Section 4 and Appendix C (FSP, 2003). If there are any questions relating to the criticality safety of a proposed action, a Criticality Safety Engineer and the Facility Safety Officer shall be contacted before proceeding.

6.1 Standard Criticality Control Conditions (SCCCs)

SCCCs A, D, G, and O are applicable to Workstation 1309. This analysis analyzed the addition of a new set of controls, SCCC Hx. Only one SCCC and its associated criticality safety controls can exist at a workstation at any one time. The entire set of possible controls is listed below for completeness.

6.1.1 Condition A

Refer to Section 4.1.2.2 of the Building 332 Facility Safety Plan for controls.

6.1.2 Condition D

Material and Form:

- A. The fissionable material shall be metal, or non-hydrogenous compounds, which may be in the form of pieces, chips, fines, or powders, and may be intermixed with moderating materials to form solutions and slurries.
- B. The fissionable material mass limits are as follows:

Pu mass is limited to 2500 g
or
 ^{235}U mass is limited to 3600 g.

Moderation:

- A. Liquid and solid moderators intermixed with fissionable material shall be limited to a total volume of one liter.
- B. Liquid and solid moderators not mixed with fissionable material shall be limited to a total volume of two liters.

Reflection:

Cladding on fissionable material is limited to a thickness of 0.25 inches.

Shape:

The shape of the fissionable material is not controlled.

6.1.3 Condition Hx

Material and Form:

Up to nine MSA cans, each with up to 3600 g of PuO₂ (3.17 kg Pu) are allowed

Moderation:

Liquid and solid moderators shall not be mixed with fissionable materials.

Reflection:

- A. Reflecting materials around the MSA cans is limited to RM-104-AOC plastic, steel or aluminum frames to hold the cans and reflectors, and instruments described in section 3 of OSP332.191.
- B. Beryllium reflectors are not allowed.

Shape:

- A. Deformation of the MSA can or its fissionable contents is not allowed.
- B. Breaching of the integrity of the MSA can is not allowed.
- C. The MSA cans may be stacked in any configuration allowed by an approved assembly plan.

6.1.4 Condition G

Material and Form:

- A. One approved item, or component parts of this approved item, from the Approved Items List for SCCC G is allowed.
- B. Chips, fines, samples, or other small pieces removed from the approved item shall be limited to a maximum of 220 g of Pu and/or ^{235}U .

Moderation:

- A. Liquid and solid moderators shall not be mixed with fissionable materials.
- B. Liquids in bottles are not controlled.

Reflection:

Cladding on fissionable materials is limited to those materials that are part of the approved item.

Shape:

The shape of the fissionable material is limited to that of the approved item. Sub-component parts shall retain the same characteristic shape as in the original approved item. Deformation of the approved item or its fissionable sub-component parts is not allowed. Any exception to this condition is specifically described in Section 3 of OSP 332.191.

6.1.5 Condition O

Material and Form:

- A. The total fissionable material mass is limited to 4,500 g of any combination of Pu and ^{235}U .
- B. Fissionable material shall be in the form of metal, oxide, or non-hydrogenous materials excluding beryllium and graphite.

Moderation: (See Section 4.6.2 of OSP332.191 for flammable liquid limits.

- A. Liquid and solid moderators shall not be mixed with fissionable materials.
- B. Total liquids in bottles cannot exceed one liter.

Reflection:

Cladding on fissionable material is limited to those materials that are part of the approved configurations.

Shape:

Material shall be in a configuration as defined in Section 4.3.3 of the Specific Criticality Controls for the workstation in OSP332.191.

6.2 Specific Criticality Controls for Workstation 1309

Note that the following previously approved controls have been included in this section for completeness.

- 6.2.1 Control – Sealed Primary Container:** Opening/repacking of sealed primary containers of SNM is strictly prohibited.
- 6.2.2 Control – WS 1309 Shielding Limit for SCCC G and Hx:** Shielding and reflectors are authorized under SCCC G or Hx if they are assembled according to an approved assembly procedure. This assembly procedure shall be approved by the RI, and reviewed by the Criticality Safety Section and the ES&H Team Leader. Approval is also required for any lead, cadmium, aluminum, copper, steel, stainless steel, lead loaded acrylic, lead loaded glass, or lead loaded glovebox gloves that may be placed in front of or around the fissionable material item to provide shielding.
- 6.2.3 Control – Overnight Storage of Samples:** Fissionable material items greater than 2500 g of Pu or greater than 3600 g of ^{235}U shall not be left overnight for measurement except those items listed in the Approved Items List for SCCC G. Materials shall not be stored in Workstations 1310 or 1311 overnight.
- 6.2.4 Control – WS 1309 ^{233}U Work for SCCC G:** Items containing ^{233}U shall only be measured under SCCC G as part of an approved item.
- 6.2.5 Control – WS 1309 SCCC D Work:** When making measurements under SCCC D, up to 1 inch of lead, cadmium, aluminum, copper, steel, stainless steel, lead loaded acrylic, lead loaded glass, or lead loaded glovebox gloves as approved equipment may be placed around or in front of the fissionable material to provide shielding.
- 6.2.6 Control – WS 1309 External Source Limit:** An external radioactive source may be used in conjunction with an approved item covered by an approved assembly procedure. These active gamma ray and neutron measurements shall be performed under SCCC G or Hx with an approved experimental procedure that covers that the use of the source has been reviewed by the Criticality Safety Section. The external source may be an intrinsic neutron generator a long as the generator is part of an approved assembly procedure as described in Section 4.3.2.2 of the OSP.
- 6.2.6 Control – WS 1309 External Reflector:** No beryllium or graphite material shall be allowed in the workstation except as part of an approved item or under SCCC A.

6.2.7 Control – Material Configuration Control: The material permitted by SCCC O shall be in one of the following configurations:

- Up to 4.5 kg of any combination of Pu and ^{235}U oxide in a 3013 container consisting of a welded inner and welded outer can which contains 3013 convenience can(s) for oxide.
- Up to 4.5 kg of any combination of Pu and ^{235}U in one 3013 container consisting of a welded inner and welded outer can which contains two 3013 convenience cans for metal each of which contains no more than 2.5 kg.

7.0 CRITICALITY HAZARD TYPE

The addition of SCCC Hx to OSP332.191 does not affect the original criticality hazard classification, which is Type 2.

8.0 CONCLUSION

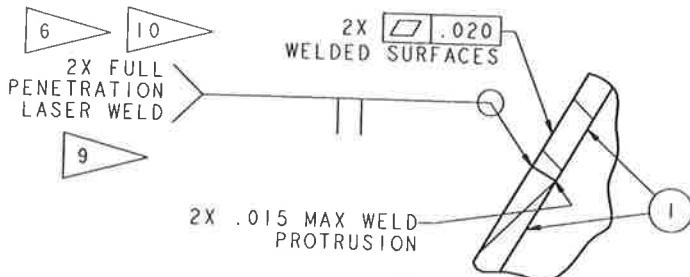
The results of this evaluation have indicated that no single credible contingency can cause a criticality event. The criticality safety controls as stated in Section 6 are sufficient to ensure criticality safety under the double contingency principle for the requested operations described in OSP 332.191 with any array of up to nine MSA cxontainers, each filled with up to 3.6 kg of plutonia, and surrounded by RM-104-AOC plastic reflector. The construction of these arrays must follow an approved assembly procedure.

9.0 REFERENCES

- Briesmeister, 2000, *LA-13709-M, MCNP™ - A General Monte Carlo N-Particle Transport Code, Version 4C*, Judith Briemeister, Editor, Los Alamos National laboratory, Los Alamos, New Mexico, 10 April 2000.
- FSP, 2003, *FSP-332-03: Plutonium Facility – Building 332 Facility Safety Plan*, Lawrence Livermore National Laboratory, Livermore, California, June 2003
- NEA, 1998, *NEA/NSC/DOC(95)03: International Handbook of Evaluated Criticality Safety Benchmark Experiments*, Nuclear Energy Agency Nuclear Science Committee, 1998

Appendix A
Measurement Standard Assembly

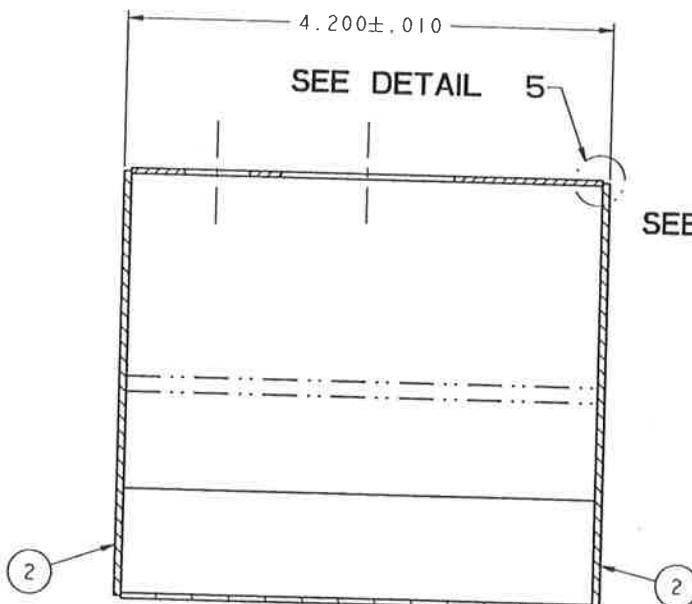
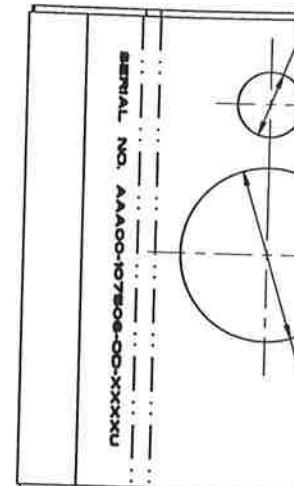
UNCLASSIFIED

DETAIL 3
SCALE 10/16X R.150±.010
ITEM 26X R.180±.010
ITEM 1(3.664) ITEM2
(3.712)DETAIL 4
SCALE 10/1

ON A 1.000 INCH DIAMETER CIRCLE

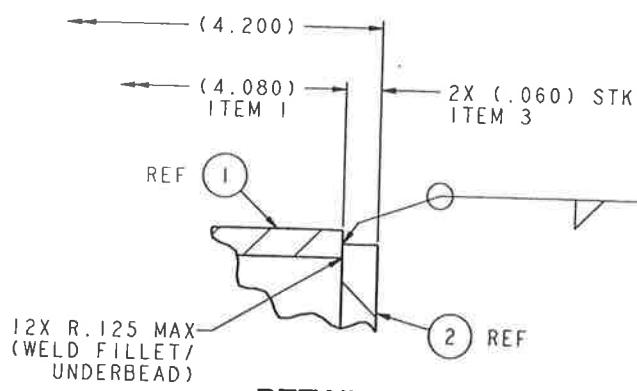
A 1.000 INCH DIAMETER CIRCLE

A 1.000 INCH DIAMETER CIRCLE



SEE DETAIL 3

SECTION B-B

DETAIL 5
SCALE 10/1

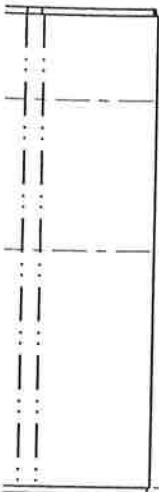
PROJ	REVISION	VERSION	RELEASE
MODEL	OP	10	REL
DRAWING	OP	#	#FL

DRAWING: 00-107506-UNC, MODEL: 00-107506-UNC, TYPE: ASSEM

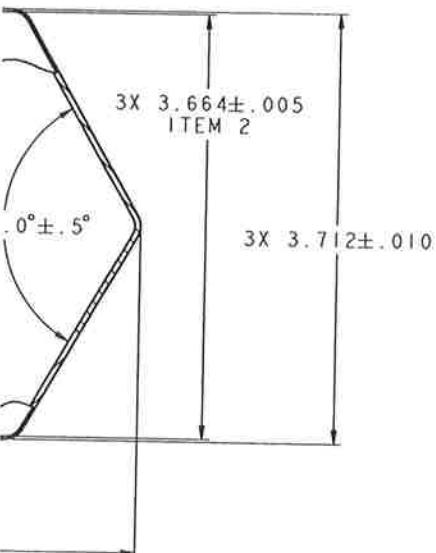
UNCLASSIFIED

UNCLASSIFIED

$\delta .563^{+.002}_{-.000}$ THRU
ONE SIDE ONLY



$\phi 1.500^{+.002}_{-.000}$ THRU
ONE SIDE ONLY



PART NUMBER	SHEET ZONE	REVISIONS	
		IS3	PREPARED BY/DESCRIPTION DATE
	0C	DRAWN: A. FAIR DESIGN: T. SHELL CHECKED: T. SHELL APPROVED: W. BISH MODIFIED MATERIAL, 316L WAS 316	3-25-02
	0D	DRAWN: A. FAIR DESIGN: T. SHELL CHECKED: T. SHELL APPROVED: W. BISH MODIFIED NOTES ADDED SHEET 2	5-2-02

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. SURFACE TEXTURE PER ANSI B46.1-1985.
SURFACE TEXTURE SYMBOLS PER ANSI Y14.36-1978.
4. WELD SYMBOLS PER ANSI/AWS A4.2-1993.
5. TO BE MANUFACTURED PER A DOCUMENTED PROCESS.
6. WELDS TO BE MADE IN AN ARGON ATMOSPHERE ENCLOSURE.
7. PRIOR TO TIG WELDING HEX ENDS,
BUT AFTER LASER WELDING SEAMS,
REMOVE TABS
8. LEAK RATE SHALL NOT EXCEED 1×10^{-7} cc He/sec
WITH CAN UNDER VACUUM.
9. WELD UNDER-BEAD TO BE PRESENT FOR
100% OF WELD LENGTH.
10. INSPECT OUTER SURFACE OF WELD AT 40X
MAGNIFICATION FOR CRACKS, VOIDS AND
OTHER DEFECTS.
11. RADIOPHGRAPH PER PROCEDURE MSCP007
QP-COTDU-2002-0291.
12. ELECTRO-CHEMICAL ETCH PART NUMBER AND SERIAL
NUMBER IN .125" HIGH CHARACTERS IN LOCATION
SHOWN. NUMBER MUST BE PLACED AT TOP LEFT OF
SURFACE TO PROVIDE SPACE FOR OTHER NUMBERS.

EXAMPLE: SERIAL NO. AAA00-107506-OD-XXXXU
13. A DATA PACKAGE CONTAINING THE FOLLOWING ITEMS
IS REQUIRED FOR EACH WELDMENT:
A: MATERIAL CERTIFICATION
B: LEAK TEST REPORT
C: DIMENSIONAL INSPECTION
D: WELD PENETRATION INSPECTION
E: WELD FOLLOW SHEET
14. HAND DRESS WELD TO REMOVE PROTRUSIONS/PEAKS
ONLY.
15. CONTAINER VOLUME IS .75 LITERS.

2	-	SHEET, .060 THK 316L SST FULL ANNEALED	0.29	0.21	2
2	-	SHEET, .048 THK 316L SST FULL ANNEALED	0.29	0.35	1
NO RECD	PART/CONTROL NO	DESCRIPTION/MATERIAL	DENSITY (LB/IN ³)	WEIGHT (LBS)	ITEM
	THIS DRAWING WAS CREATED BY THE UNIVERSITY OF CALIFORNIA THAT OPERATES LAWRENCE LIVERMORE NATIONAL LABORATORY FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. W-7405-ENG-48 ("LLNL"). ANY REPRODUCTION AND/OR FABRICATION IS PROHIBITED WITHOUT THE PERMISSION OF LLNL. A HARDCOPY OF THIS DRAWING IS UNCLASSIFIED. HOWEVER, THE ASSOCIATED DATA WAS ORIGINATED ON THE CLASSIFIED NETWORK AND REMOVAL FROM THE CLASSIFIED NETWORK SHALL ONLY BE PER A DOE APPROVED PROCEDURE.				
	QUANTITY: NR = NO QUANTITY FOR DOCUMENTS ALT = ALTERNATE FM = PROCESS MATERIAL AR = AS REQUIRED FOR ASSEMBLY DRAWING: 00-107506-UNC MODEL: 00-107506-UNC TYPE: ASSM LAWRENCE LIVERMORE NATIONAL LABORATORY DRAWING CLASSIFICATION: UNCLASSIFIED ENGLISH THIRD ANGLE PROJECTION				
	MEASUREMENT STD ASSY HEX BOX WELDMENT (U) DRAWING NUMBER: E AAA00-107506 OD ISSUE: E DRAWING NUMBER: AAA00-107506 OD SCALE: 2/1 SHEET 1 OF 2 ORIGIN: LL-PRO/E-R2000I STATUS: LL-REL-5-2-02				

UNCLASSIFIED

10. WELD IN HELIUM GAS ATMOSPHERE.

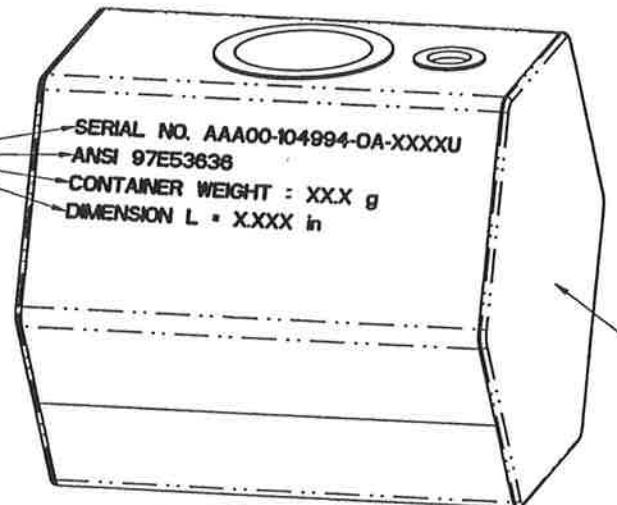
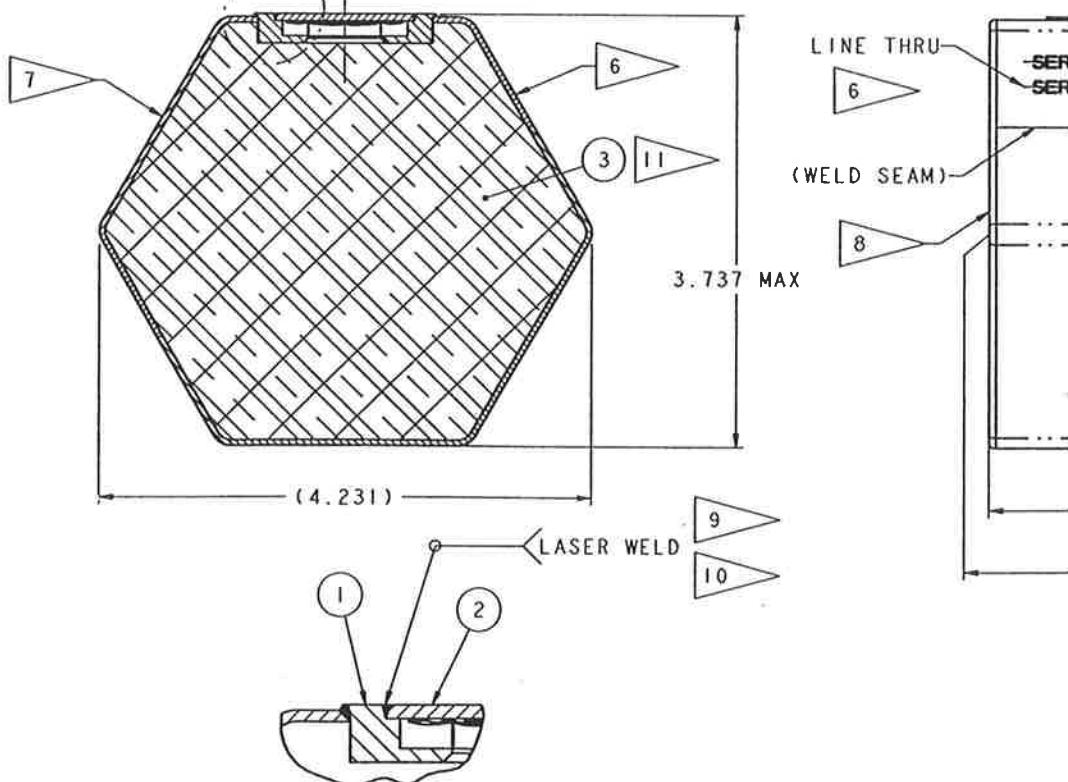
11. FLOW HELIUM GAS INTO CONTAINER DURING POWDER FILL.

12. RECORD WEIGHT OF FILLED AND SEALED CONTAINER TO NEAREST 0.1g.

13. RECORD DIMENSION "L" AT CENTER OF HEX ENDS WITHIN A Ø.50" ZONE TO 3 DECIMAL PLACES.

14. SEE DRAWING 02-100405 FOR FRIT SEAL LID.

SEE DETAIL 2

PICTORIAL VIEW
SCALE 2/1DETAIL 2
SCALE 4/1

NAME:FAIRI DATE:10-Jul-02 13:54:55

:CT:00-104994-UNC

PROJ	RECS	SILO	VER100	RELEASE
MODEL	1	3	911	
DRAWING	0	1	421	

DRAWING: 00-104994-UNC, MODEL: 00-104994-UNC, TYPE: ASSEM

UNCLASSIFIED

UNCLASSIFIED

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. SURFACE TEXTURE PER ANSI B46.1-1985.
SURFACE TEXTURE SYMBOLS PER ANSI Y14.36-1978.
4. WELD SYMBOLS PER ANSI/AWS A4.2-1993.
5. LEAK RATE SHALL BE LESS THAN 1×10^{-7} cc He(STD)/sec.

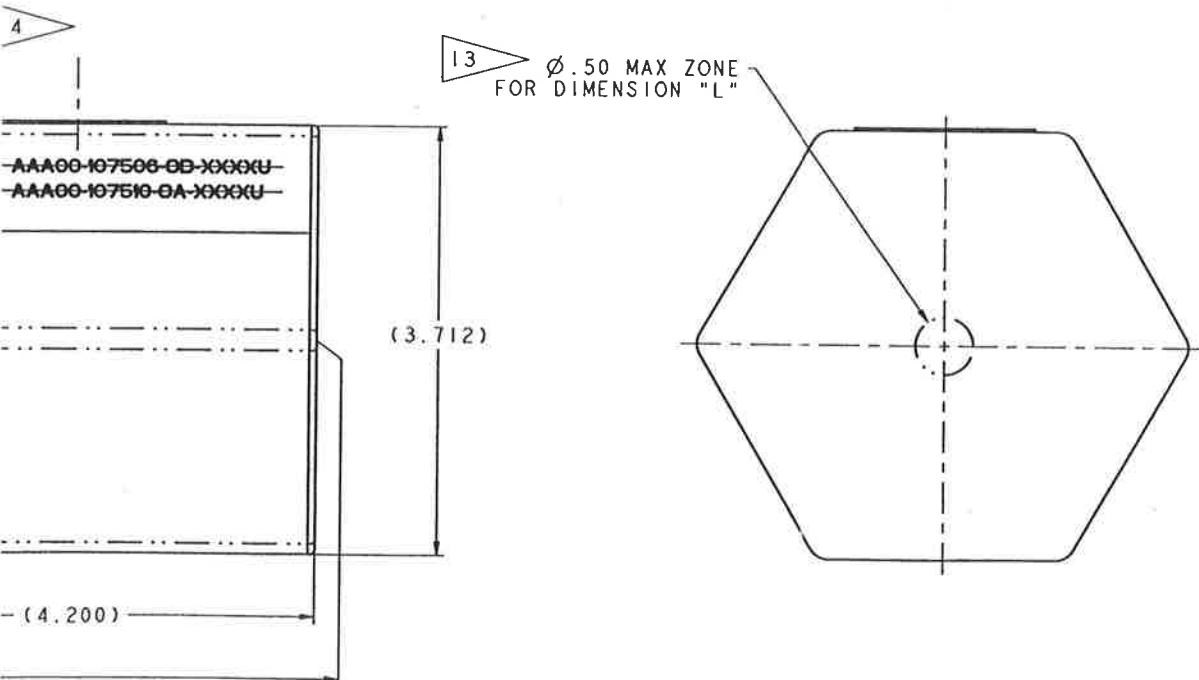
PART NUMBER	ISSUE SHEET ZONE	REVISIONS	
		PREPARED BY/DESCRIPTION	DATE
-	00	DRAWN: A. FAIR DESIGNED: M. ENGEL CHECKED: T. SHELL APPROVED: W. BISH ORIGINAL ISSUE	4-27-01
-	0A	DRAWN: A. FAIR DESIGNED: A. FAIR CHECKED: T. SHELL APPROVED: W. BISH MODIFIED NOTES ADDED DIMENSION "L"	4-22-02

6. LINE THRU BUT DO NOT OBLITERATE ALL EXISTING MARKINGS ON THIS SURFACE, IF NOT LINED THRU ALREADY.
7. ELECTRO-CHEMICAL ETCH IN .125" HIGH CHARACTERS IN APPROXIMATE LOCATION SHOWN. INPUT PER ENGINEERING.

EXAMPLE:

SERIAL NO. AAA00-104994-OA-XXXXU
ANSI 97E53636
CONTAINER WEIGHT = XX.X g
DIMENSION L = X.XXX in

8. THIS SIDE TO BE MARKED, BY ELECTRO-ETCHING, PER ENGINEERING INSTRUCTIONS.
9. VISUALLY INSPECT WELD AT 40X MAGNIFICATION.



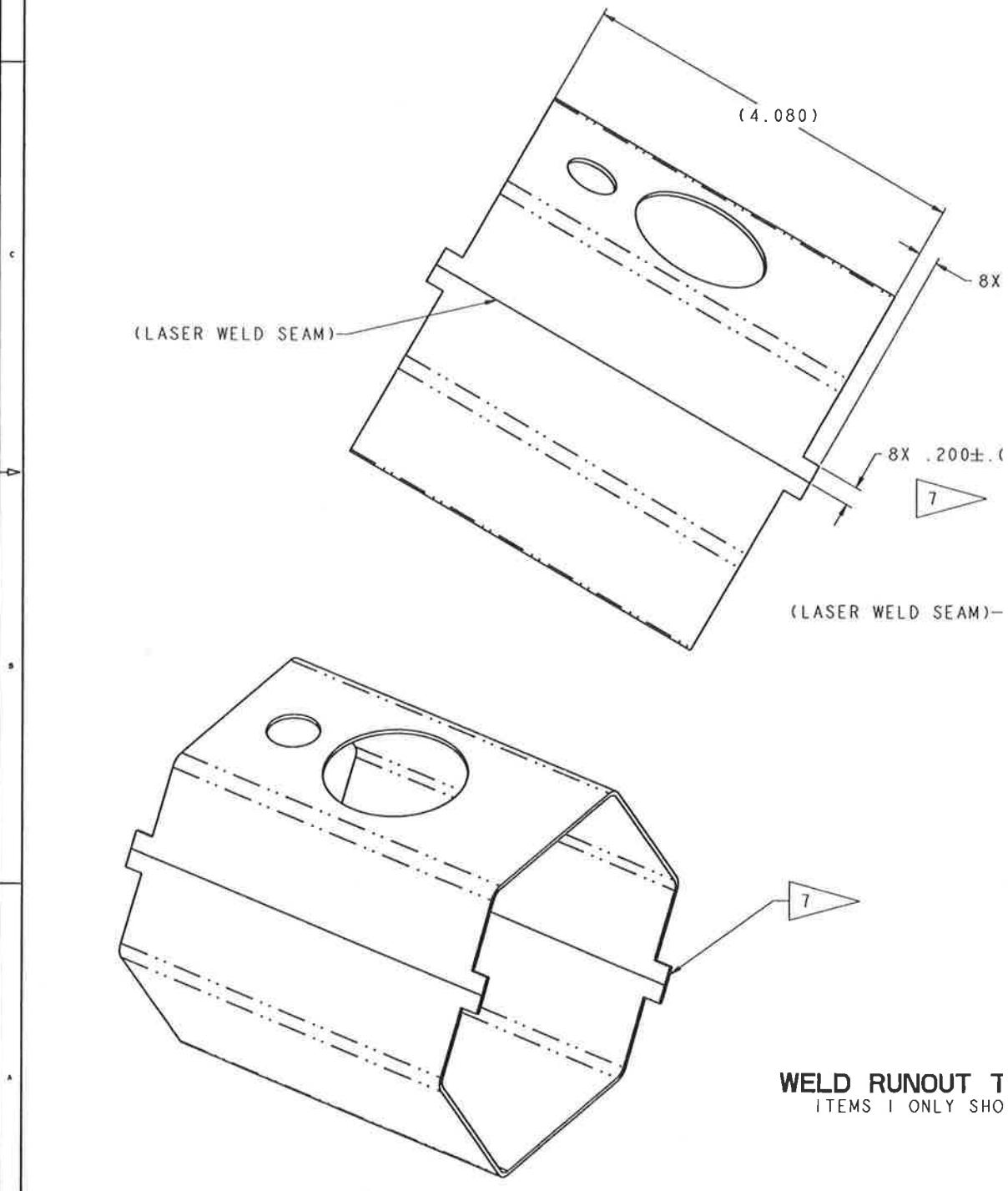
AR	PART/CONTROL NO	DESCRIPTION/MATERIAL	DENSITY (LB/IN ³)	WEIGHT (LBS)	ITEM
I	00-107501	SEAL PLATE	SST	2	3
I	00-107510	CONTAINER ASSY	SST	1	2
NO REOD					

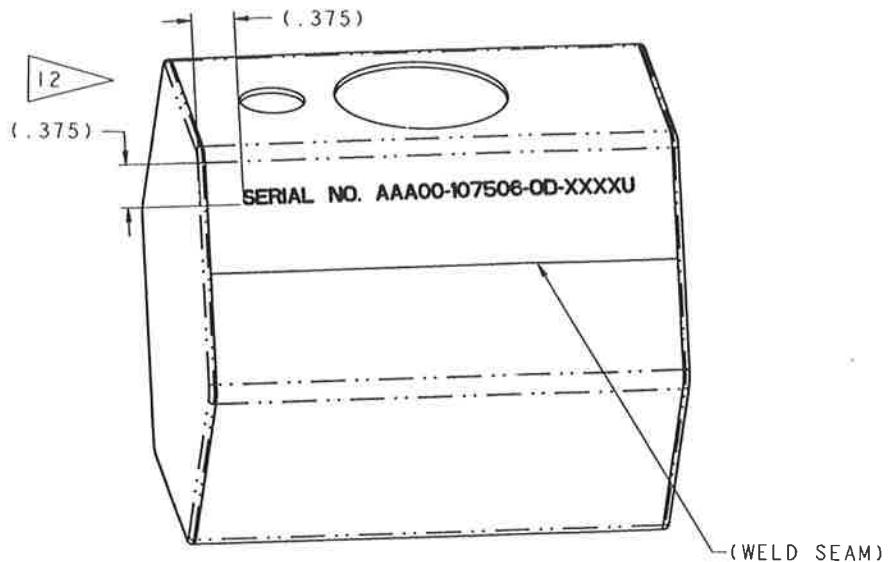
THIS DRAWING WAS CREATED BY THE UNIVERSITY OF CALIFORNIA THAT OPERATES LAWRENCE LIVERMORE NATIONAL LABORATORY FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. W-7405-ENG-48 ("LLNL"). ANY REPRODUCTION AND/OR FABRICATION IS PROHIBITED WITHOUT THE PERMISSION OF LLNL. A HARDCOPY OF THIS DRAWING IS UNCLASSIFIED; HOWEVER, THE ASSOCIATED DATA WAS ORIGINATED ON THE CLASSIFIED NETWORK AND REMOVAL FROM THE CLASSIFIED NETWORK SHALL ONLY BE PER A DOE APPROVED PROCEDURE.

QUANTITY: 1A = NO QUANTITY FOR DOCUMENTS PM = PROCESS MATERIAL AR = AS REQUIRED
SPECIFICATIONS: ALT = ALTERNATE EM = EXPENSE MATERIAL AR = AS REQUIRED FOR ASSEMBLY
DRAWING: 00-104994-WK
MODEL: 00-104994-WK
TYPE: ASSM
LAWRENCE LIVERMORE NATIONAL LABORATORY
ENGLISH
THIRD ANGLE PROJECTION

1/4" X 1/4" X 1/4"	MEASUREMENT STD ASSY
UNCLASSIFIED	FILLED CONTAINER ASSY (U)
DRAWING CLASSIFICATION	SIZE DRAWING NUMBER
UNCLASSIFIED	E AAA00-104994 OA
DRAWING CLASSIFICATION	CANEC 14067 SCALE 2/1 SHEET 1 OF 1
UNCLASSIFIED	ORIGIN LL-PRO/E-R2000 STATUS LL-REL-4-22-02

UNCLASSIFIED

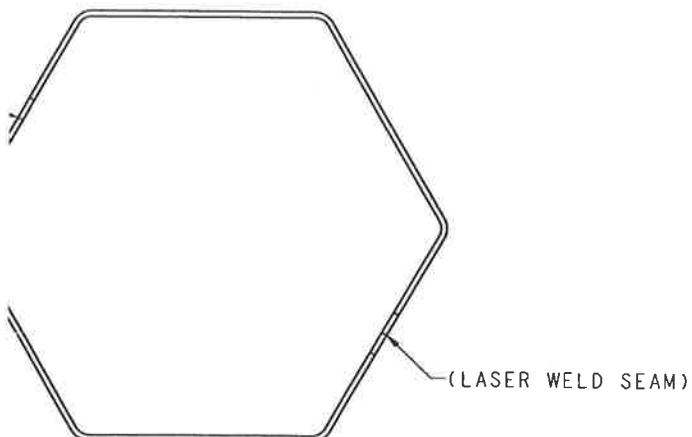




PICTORIAL VIEW
SCALE 2/1

± .030

>



DRAWING NUMBER	AAA00-107506
/ / / / /	
DRAWING CLASSIFICATION	UNCLASSIFIED
SIZE	CAGEC 14067 SCALE 2/1
E	ISSUE OD SHEET 2 OF 2
STATUS	LL - REL - 5-2-02

APPENDIX B: Sample Input Decks

```

91lathe2p5
Nine "Bish" Cans in a RM-05-H3 Lattice
c          One overpacked can
c          1-7-1
c          (9lathe0dbl)
c
c          Cell Description
c          Bish Can - Universe 2
c
1   1   -4.632 -2 1 -3 4 -5 6 -8 7      u=2 imp:n=1
$ PuO2
2   2   -7.83  -10 9 -11 12 -13 14 -16 15      u=2 imp:n=1
$ Steel Can
3   9   -1.27  10:-9:11:-12:13:-14:16:-15      u=2 imp:n=1
$ RM-104-AOC
c
c          Overbatched Bish Can - Universe 3
c
4   1   -7.50  -2 1 -3 4 -5 6 -8 7      u=3 imp:n=1
$ PuO2
5   2   -7.83  -10 9 -11 12 -13 14 -16 15      u=3 imp:n=1
$ Steel Can
6   7   -1.27  10:-9:11:-12:13:-14:16:-15      u=3 imp:n=1
$ RM-104-AOC
c
c          The Hexagonal Universe
c
7   7   -1.27    -99      fill=1 imp:n=1
$ RM-104-AOC
c
c          The Hexagonal Lattice
c
8   7   -1.27  -18 17 -19 20 -21 22 -24 23      u=1 lat=2 imp:n=1
fill=-12:12 -12:12 -11:11
$ Hexagonal Element
c
c          x=-12 -10 -8 -6 -4 -2   0   2   4   6   8   10
12
c          -11  -9  -7  -5  -3  -1   1   3   5   7   9
11
c
c          z=-11
1 1 $ y=-12
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-11
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-10
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-9
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-8
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-7
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-6
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-5
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-4
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-3
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=0
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=3
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=4
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=5
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=6
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=7
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=8
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=9
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=10
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=11
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=12
c
c          x=-12 -10 -8 -6 -4 -2   0   2   4   6   8   10
12
c          -11  -9  -7  -5  -3  -1   1   3   5   7   9
11
c
c          z=-9
1 1 $ y=-12
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-11
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-10
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-9
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-8
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-7
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-6
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-5
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-4
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-3
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=0
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=3
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=4
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=5
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=6
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=7
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=8
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=9
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=10
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=11
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=12
c
c          x=-12 -10 -8 -6 -4 -2   0   2   4   6   8
10 12
c          -11  -9  -7  -5  -3  -1   1   3   5   7   9
11

```



```

1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9
c
c      z=4
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9
c
c      z=5
1 1 $ y=-12

```

```

1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2   0   2   4   6   8   10
12
c      -11  -9  -7  -5  -3  -1   1   3   5   7   9
11
c
c      z=6
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2   0   2   4   6   8   10
12

```



```

1 1 $ y=8      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=9      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=10     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=11     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=12     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
c
c      x=-12 -10 -8 -6 -4 -2   0   2   4   6   8   10
12
c      -11  -9  -7  -5  -3  -1   1   3   5   7   9
11
c
c      z=11
1 1 $ y=-12    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-11    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-10    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-9     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-8     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-7     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-6     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-5     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-4     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-3     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-2     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=-1     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=0      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=1      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=2      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=3      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=4      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=5      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=6      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=7      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=8      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=9      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=10     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=11     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 $ y=12     1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
c
c      Borders of the World
c
9 0          99          imp:n=0
$ Void

c      Surface Descriptions
c
c      Contents of Can
c
c      Hexagonal Surfaces
c
1 | p      px =-4.6533
2 | p      px  4.6533
$ | l
c
$ | u
c | t      (Ax + By + CZ = D)
c | o      A      B      C      D
3 | p      0.50  0.8660254 0.0   4.6533
4 | n      p      0.50  0.8660254 0.0  -4.6533
5 | i      p      -0.50 0.8660254 0.0   4.6533
6 | u      p      -0.50 0.8660254 0.0  -4.6533
$ | m
c
$ | 
c | x      Ends of the Contents
$ | o
$ | x
7 | p      pz =-5.1815
8 | p      pz  5.1815
$ | d

c      e      Steel Can
c
c      Hexagonal Surfaces
9 | p      px =-4.7140
10 | p     px  4.7140
$ | 
c
$ | B      (Ax + By + CZ = D)
c | i      A      B      C      D
11 | p     0.50  0.8660254 0.0   4.7140
12 | p     0.50  0.8660254 0.0  -4.7140
$ | 
c
$ | s      -0.50 0.8660254 0.0   4.7140
14 | p     -0.50 0.8660254 0.0  -4.7140
$ | 
c
$ | n      Ends of the Can
c
c      Hexagonal Lattice Element
c
c      Hexagonal Surfaces
c
17 | p      px =-4.7141
18 | p     px  4.7141
$ | 
c
$ | x      (Ax + By + CZ = D)
c | a      A      B      C      D
19 | p     0.50  0.8660254 0.0   4.7141
20 | p     0.50  0.8660254 0.0  -4.7141
$ | 
c
$ | g      -0.50 0.8660254 0.0   4.7141
22 | p     -0.50 0.8660254 0.0  -4.7141
$ | 
c
$ | 
c | c      Ends of the Cell
$ | 
c
$ | e      -5.3341
24 | p     pz  5.3341
$ | 
c
c      so      100
$ The End of the World
c
c      Materials
c
c      PuO2
c
m1      94239  -0.882
Pu-239   8016   -0.118
o
c
c      316L Stainless Steel (ASTM) (7.83
g/cc)
c
m2      6000  -0.0003000
C       25055 -0.0200000
Mn      15031 -0.0004500
P       16000 -0.0003000
S       14000 -0.0100000
Si      24000 -0.2000000
Cr      28000 -0.1400000
Ni      42000 -0.0300000
Mo      7014  -0.0009963
N-14    7015  -0.0000037
N-15    26000 -0.5979500
Fe
c

```



```

1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9
c
c      z=-9
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10

```



```

1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2  0   2   4   6   8   10
c      -11 -9 -7 -5 -3 -1   1   3   5   7   9
c
c      z=-2
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2  0   2   4   6   8   10
c      -11 -9 -7 -5 -3 -1   1   3   5   7   9
c
c      z=-1
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1

```



```

1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9
c
c      z=8
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9

```



```

10    px     4.7140
$ |
c
$ | B
c      (Ax + By + CZ = D)
$ | i
c      A       B       C       D
$ | s
11   p     0.50   0.8660254  0.0   4.7140
$ | h
12   p     0.50   0.8660254  0.0  -4.7140
$ |
13   p    -0.50   0.8660254  0.0   4.7140
$ | C
14   p    -0.50   0.8660254  0.0  -4.7140
$ | a
c
$ | n
c      Ends of the Can
$ |
c
$ |
15   pz    -5.3340
$ |
16   pz     5.3340
c
c      Hexagonal Lattice Element
c
c      Hexagonal Surfaces
$ | H
17   px    -4.7141
$ | e
18   px     4.7141
$ | x
c      (Ax + By + CZ = D)
$ | a
c      A       B       C       D
$ | g
19   p     0.50   0.8660254  0.0   4.7141
$ | o
20   p     0.50   0.8660254  0.0  -4.7141
$ | n
21   p    -0.50   0.8660254  0.0   4.7141
$ | a
22   p    -0.50   0.8660254  0.0  -4.7141
$ | l
c
$ | c
c      Ends of the Cell
$ | e
23   pz    -5.3341
$ | l
24   pz     5.3341
c
c
99   so     100
$ The End of the World

c
c      Materials
c
c      PuO2
$ |
m1   94239   -0.882
Pu-239
$ |
o
c      316L Stainless Steel (ASTM) (7.83
g/cc)
$ |
m2   6000   -0.0003000
C
$ |
Mn   25055   -0.0200000
$ |
P    15031   -0.0004500
$ |
S    16000   -0.0003000
$ |
Si   14000   -0.0100000
$ |
Cr   24000   -0.2000000
$ |
Ni   28000   -0.1400000
$ |
Mo   42000   -0.0300000
$ |
N-14  7014   -0.0009963
$ |
N-15  7015   -0.0000037
$ |
Fe
c
c      Water (1.00 g/cc)
c
m3   1001   -0.1119
H
$ |
O
mt3  8016   -0.8881
$ |
Light Water

```

			Air (0.00129 g/cc)	
c				\$
c			7014 -0.78084	\$
m4			8016 -0.20982	\$
N			18000 -0.00934	\$
O				
Ar				
c			RM-05-20H Plastic (1.45 g/cc)	
c				
m5			1001 -0.0434	\$
H			6000 -0.3016	\$
c			7014 -0.1475	\$
N-14			7015 -0.0005	\$
N-15			8016 -0.5070	\$
O			poly.01t	\$
mt5				
H in Poly			RM-05-H3 Plastic (1.45 g/cc)	
c				
m6			1001 -0.0450	\$
H			6000 -0.3260	\$
C			7014 -0.1684	\$
N-14			7015 -0.0006	\$
N-15			8016 -0.4600	\$
O			poly.01t	\$
mt6				
H in Poly			RM-104-AOC Plastic (1.27 g/cc)	
c				
m7			1001 -0.0462	\$
H			6000 -0.3302	\$
C			7014 -0.1684	\$
N-14			7015 -0.0006	\$
N-15			8016 -0.4870	\$
O			poly.01t	\$
mt7				
H in Poly			Concrete (2.24 g/cc)	
c				
m8			1001 -0.009959	\$
H			6000 -0.000979	\$
C			8016 -0.529069	\$
O			11023 -0.016003	\$
Na			12000 -0.002000	\$
Mg			13027 -0.034006	\$
Al			14000 -0.337036	\$
Si			19000 -0.012981	\$
K			20000 -0.043965	\$
Ca			26000 -0.014002	\$
Fe			poly.01t	\$
mt8				
H in poly			Beryllium (1.048 g/cc)	
c				
m9			4009 1.000	\$
Be-9				
c				
mode n				
kcode			1000 1.0 10 100	
ksrc			0.0 0.0 0.0	
print				

```

1 1 $ y=-12
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
12
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9
11
c
c      z=-9
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
12

```



```

1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2  0  2  4  6  8 10
12
c      -11 -9 -7 -5 -3 -1  1  3  5  7  9
11
c
c      z=-2
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2  0  2  4  6  8 10
12
c      -11 -9 -7 -5 -3 -1  1  3  5  7  9
11
c
c      z=-1
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12

```

```

1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
12
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9
11
c
c      z=0
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
12
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9
11
c
c      z=1
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2

```

```

1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
12
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9
c
c      z=2
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5
1 1 $ y=-4
1 1 $ y=-3
1 1 $ y=-2
1 1 $ y=-1
1 1 $ y=0
1 1 $ y=1
1 1 $ y=2
1 1 $ y=3
1 1 $ y=4
1 1 $ y=5
1 1 $ y=6
1 1 $ y=7
1 1 $ y=8
1 1 $ y=9
1 1 $ y=10
1 1 $ y=11
1 1 $ y=12
c
c      x=-12 -10 -8 -6 -4 -2 0 2 4 6 8 10
12
c      -11 -9 -7 -5 -3 -1 1 3 5 7 9
c
c      z=3
1 1 $ y=-12
1 1 $ y=-11
1 1 $ y=-10
1 1 $ y=-9
1 1 $ y=-8
1 1 $ y=-7
1 1 $ y=-6
1 1 $ y=-5

```



```

c
c          Air   (0.00129 g/cc)
c
m4      7014   -0.78084      $
N       8016   -0.20982      $
O       18000  -0.00934      $
Ar
c
c          RM-05-20H Plastic (1.45 g/cc)
c
m5      1001   -0.0434      $
H       6000   -0.3016      $
C
N-14    7014   -0.1475      $
N-15    7015   -0.0005      $
O       8016   -0.5070      $
mt5    poly.01t      $
H in Poly
c
c          RM-05-H3 Plastic (1.45 g/cc)
c
m6      1001   -0.0450      $
H       6000   -0.3260      $
C
N-14    7014   -0.1684      $
N-15    7015   -0.0006      $
O       8016   -0.4600      $
mt6    poly.01t      $
H in Poly
c
c          RM-104-AOC Plastic (1.27 g/cc)
c
m7      1001   -0.0462      $
H       6000   -0.3302      $
C
N-14    7014   -0.1684      $
N-15    7015   -0.0006      $
O       8016   -0.4870      $
mt7    poly.01t      $
H in Poly
c
c          Concrete (2.24 g/cc)
c
m8      1001   -0.009959     $
H       6000   -0.000979     $
C
O       8016   -0.529069     $
Na      11023  -0.016003     $
Mg      12000  -0.002000     $
Al      13027  -0.034006     $
Si      14000  -0.337036     $
K       19000  -0.012981     $
Ca      20000  -0.043965     $
Fe
mt8    poly.01t      $
H in poly
c
c          Beryllium (1.848 g/cc)
c
m9      4009   1.000        $
Be-9
c
mode n
kcode  1000 1.0 10 100
ksrc  0.0 0.0 0.0
print

```

APPENDIX C:
Notes from William Bish
Received 13 March 2003

4/19/05 WRIS

MS CONTAINER PRESSURE @ 800°C

A MS CONTAINER FILLED WITH SURROGATE MATERIAL WILL BE TESTED @ 800°C IN ANSI TEST, TO BE CONDUCTED IN MARCH.

CONTAINER PRESSURE CALCULATIONS:

I. FILLED WITH IDEAL GAS @ STP

$$T_1 = 20^\circ\text{C} \quad P_1 = \underline{14.7 \text{ psia}}$$

$$= \underline{\frac{293}{273} \text{ atm}}$$

$$T_2 = 800^\circ\text{C} + 273 = \underline{1073^\circ\text{K}}$$

$$P_2 = \frac{T_2}{T_1} P_1 = \frac{1073}{293} (14.7) = \underline{54 \text{ psia}}$$

II. PRESSURE IN FILLED CAN WITH 1.44 gm H₂O

Pu OXIDE WILL BE CALCINED @ 1000°C;
PROTECTED FROM MOISTURE PICK UP UNTIL SEALED
IN MS CONTAINER. UNCERTAINTIES COULD
ALLOW UP TO 1.44 gm OF H₂O* (VERY UNLIKELY),
HOWEVER, PRESSURE @ 800°C WITH 1.44 gm
H₂O IS:

CAN FREE VOLUME WITH POWDER AT HIGHEST
P: 4.0 g/cc Pu OXIDE SOLID P = 11.5 g/cc

EMPTY CAN FREE VOL = 0.75 L

$$\text{VOID FRACTION} = 1 - \frac{4.0}{11.5} = 1 - .35 = .65$$

FILLED CAN, VOID VOL = (.65)(.75L) = .488 L

1 gm mole H₂O VAPOUR @ STP VOL = 22.4 L

$$1.44 \text{ gm H}_2\text{O} = \frac{1.44}{18} = .08 \text{ gm MOLE}$$

$$\text{VOL @ STP} = (0.08)(22.4 \text{ L}) = 1.79 \text{ L}$$

PRESSURE IN CAN WITH POWDER & .08 gm mole H₂O VA
@ 800°C (NO H₂O DISSOCIATION), P_M ~~TOTAL PRESSURE~~

$$P_M = \frac{1073}{293} (14.7) \frac{1.79}{.488} = \underline{198 \text{ psia}} = \cancel{198 \text{ psia}}$$

* FROM NMTP-02-142 10/10/02

~~54 psia~~
54 psia

TOTAL PRESSURE IN CAN @ 800°C P_{T800}

$$P_{T800} = \frac{198 \text{ psia}}{54 \text{ psia}} H_2O \quad H_2 \& N_2 \\ = \boxed{252 \text{ psia}}$$

A PRODUCTION CERTIFIED CAN WAS PRESSURIZED TO
1100 PSIG AND DID NOT FAIL. ($\sim RT$)

STRENGTH PROPERTIES OF 316L DECREASE
 $\approx 25\%$ AT 800°C, $(.75)(1100) = 825 \text{ psig}$

$$\therefore \text{MIN FAILURE S.F. (ROUGH)} = \frac{825 \text{ psia}}{252 - 14.7} = \underline{\underline{3.5}}$$